WATER SOFTENING— EFFECTIVENESS AT WHAT HARDNESS LEVEL

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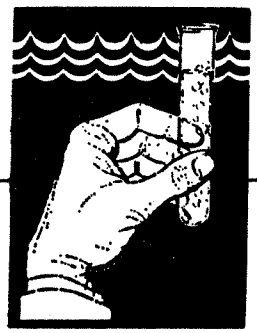

The following technical information has been assembled to assist a member of the Water Quality Association who must factually respond to the question: "At what level of water hardness will ion exchange water softening be effective?"

WATER QUALITY ASSOCIATION
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The purpose of the **Water Quality Association** is to foster an environment conducive to the growth of the water quality improvement industry. The primary objectives are:

- Proactively address legislative and regulatory issues
- Expand education opportunities and enhance technical expertise
- Broaden the acceptance of the industry

Water Quality Association

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In order to properly respond to this question, it is important to first establish a classification of water hardness that has been well accepted by governmental agencies and the water conditioning industry.

Soft Water	0 to 1 grain per gallon	0-17.1 ppm
Slightly Hard Water	1 to 3½ grains per gallon	17.1-60 ppm
Moderately Hard Water	3½ to 7 grains per gallon	60-120 ppm
Hard Water	7 to 10½ grains per gallon	120-180 ppm
Very Hard Water	Over 10½ grains per gallon	Over 180 ppm

The following information is supplied as supporting documents for the above listed classifications:

1. **Summary Appraisals of the National's Ground—Water Resources—South Atlantic—Gulf Region—Geological Survey Professional Paper 813-0, dated 1979, U.S. Department of the Interior.** In this report, the following classification is used for water hardness in terms of the amount of calcium carbonate (or its equivalent) that it contains:

0-60 mg/L	Soft
61-120 mg/L	Moderately Hard
121-180 mg/L	Hard
More than 180 mg/L	Very Hard

2. **Water Atlas of the United States—A Water Information Center Publication—1973.** It states the following on Plate 41:

> "The term 'hardness' is applied to the soap-neutralizing power of a water. It is the characteristic of water that shows itself in the increased quantity of soap required to produce a lather, and by the insoluble mineral scale deposited in boilers and kettles when such water is heated or evaporated. For the most part, hardness is attributable to calcium and magnesium in the water. Water having a hardness of less than 60 ppm (parts per million) is considered soft. A hardness of 60 to 120 ppm does not seriously interfere with the use of water for most purposes, although the consumption of soap is increased somewhat. Water having a hardness of more than 120 ppm is rated as hard, and is commonly softened when used for domestic and some industrial purposes. The map shows five separate patterns for the hardness of surface waters in the United States.
>
> "Hardness is due mainly to the composition of the soils and rocks over which the water moves. In general, rocks of the limestone variety, which are readily soluble, are the basic source of much of the hard water in the Nation. In addition, regions where saline waters are naturally present (see Plates 37, 38, and 39) also have higher percentages of hard water."

It would appear from the reference documents that the classifications of water hardness over 60 ppm (mg/L) would be considered, at least, moderately hard. The following four references identify a hardness level at which the softening process may be considered effective.

1. **Private Water Systems—Midwest Plan Service—Iowa State University, Ames, Iowa, MWPS-14, Copyright 1968,** states the following on page 49:

> "Water containing less than 60 mg/L (3.5 gpg) hardness minerals is generally not softened because this small amount will not cause unreasonable damage . . ."

2. **Home Water Supply Treatment—Cooperative Extension Service College of Agriculture and Natural Resources, The University of Connecticut, Storrs 70-69** which states the following:

> "For Connecticut the suggested hardness level, at which point a water softener may be desirable for domestic use, is 85 mg/L or more."

3. **Manual of Individual Water Supply Systems—Environmental Protection Agency Water Supply Division—Reprinted 1975—Park IV Water Treatment** states the following on page 86:

> "The ion-exchange method of softening water is relatively simple and can be easily adapted to the small or individual water supply system. Only a portion of the hard water

needs to be passed through the softening process because the exchange process produces water of zero hardness. The processed water can then be mixed with the hard water in proportions to produce a final water with a hardness between 50 to 80 mg/L (3 to 5 grains per gallon)."

4. **Drinking Water and Health—Advisory Center on Toxicology Assembly of Life Sciences National Research Council National Academy of Sciences, 1977, Funded by U.S. Environmental Protection Agency ISBN 0-309-02619-9** states on page 439 the following:

> "There are no distinctly defined levels for what constitutes a hard or a soft water supply. Generally, water with less than 75 mg/L (ppm) of $CaC0_3$ is considered soft and above this concentration as hard."

Even though none of the references concur as to a specific level at which softening would be effective, it appears that the range would be between 50-85 mg/L (3-5 grains per gallon).

The economics that may be attributed to softened water for commercial purposes have been documented many times. Mr. Lee Johnston of the American Institute of Laundering presented a paper at the Sixth Water Quality Symposium describing the use of softened water in commercial laundering. In this presentation, Mr. Johnston outlined the results of a laundry operation on both 5 grains per gallon hard water and "0" soft water. The costs of operating on 5 gpg hard water was almost twice the cost of operating on softened water.

A study case by Joseph E. Mears described in detail the benefits of softened water at the Benjamin Franklin Hotel in Philadelphia:

1. Linen life was almost doubled.
2. Laundry soap consumption dropped from 3 lbs. per load to 1¼ lbs. per load.
3. Due to the reduction in soap usage, washing times were reduced by 6 to 8 minutes per load which is energy conservative by reducing hot water consumption.
4. The downtime on six 305 HP boilers was decreased appreciably with a savings of 50 man hours per month per boiler.

Some years ago an article appeared in **The Laundryman** entitled "How Soft Water Lengthens Linen Supply Life" by Mr. L. H. Hein. This study covered a ten-year period on service life of linen supply. The results were remarkable in that the various linens all lasted longer after being washed in softened water with a range of 10.4% to 39% increase in life expectancy.

These examples are an indication of the economics that are directly attributed to the use of softened water. Even though the pattern of water usage for domestic application varies considerably from commercial use, there is, we feel, excellent economics and energy savings obtained with the use of "0" soft water in the home. The writer prepared a document which incorporated results of the above studies as well as additional data to support the savings that may be attributed to softened water. This report, entitled **Energy Conservation vs. Softened Water,** supports the statement that "softened water plays an active role in the conservation of our natural resources by materially reducing the need for cleaning materials and improving the life of our cloth products. It also helps control environmental pollution through a substantial reduction in the amount of soaps, detergents, and other cleaning wastes which enter our lakes and streams."

The use of softened water has been shown to dramatically increase the efficiency of both gas and electric water heaters. The results of a year-long study performed by the New Mexico State University showed that used gas water heaters operated and tested exclusively on hard water only consumed an average of 29.5% more BTU of energy than the used gas units operated and tested exclusively on softened water for the same amount of energy delivered in the form of hot water. The results of a similar series of tests on electric water heaters showed that the heaters operating on hard water consumed an average of 21.7% more BTU of energy than those operating on softened water. Obviously the amount of savings will vary with the water hardness, cost of energy, etc.; and any consumer must review his specific situation to determine his expected results.

We should feel confident that the softening of water with a hardness level of 3½ grains per gallon (60 ppm) or more is effective in the area of economics as well as energy savings.